

Three new species of Xiphidiocercariae from the thiariid snail *Thiara tuberculata* in Palakkad, Kerala, India

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Abstract Three new species of *Xiphidiocercous cercariae*, *Cercaria* sp. IX Malabar n.sp., *Cercaria* sp. X Malabar n.sp. and *Cercaria* sp. XI Malabar n.sp. were recovered from the thiariid snail *Thiara tuberculata* collected from freshwater bodies in the Palakkad district of Kerala. The three new species are described in detail and compared with their related species to establish their systematic position.

Keywords *Xiphidiocercous Cercaria* · Sporocyst · *Thiara tuberculata*

Introduction

The freshwater snails of the Palakkad district of Kerala have not been a subject of any extensive investigation for the larval trematodes infecting them. The available information is limited to the report of 5 cercariae by Mohandas (1976, 1979, 1981): *Cercaria* sp. I Kerala Mohandas 1976 from *Indoplanorbis exustus*, *Cercaria* sp. II Kerala Mohandas 1979 and *Cercaria* sp. Kerala III Mohandas 1981 from *T. tuberculata*. *Cercaria* sp. VII Kerala Mohandas 1981 and *Cercaria* sp. Kerala VIII Mohandas 1981 from *Lymnaea luteola*. A preliminary survey of freshwater snails in different waterbodies of Malampuzha and Kavassery in Palakkad district revealed the occurrence of three species of Xiphidiocercariae from the thiariid snail, *T. tuberculata*. The name xiphidiocercaria was coined by Luhe (1909) for the group of non-oculate distome cercariae in which the tail is

slender and a stylet is present at the round anterior end. Development of these cercariae occurs in sporocysts and encystment takes place in intermediate hosts.

Comparison of characters of the present cercariae with related species revealed that these are distinctly different from the others, and are therefore, reported here as *Cercaria* sp. IX Malabar n.sp., *Cercaria* sp. X Malabar n.sp. and *Cercaria* sp. XI Malabar n.sp.

Materials and methods

The freshwater snails *T. tuberculata*, collected from different water bodies of Malampuzha and Kavassery in Palakkad district of Kerala during November 2005–August 2006, were brought alive to the laboratory and screened for cercariae. Details of host collected and localities surveyed are presented here.

Localities of collection	Period of collection	Number of snails collected
Malampuzha	November 2005	75
	December 2005	125
	February 2006	50
	June 2006	200
	August 2006	250
	August 2006	260
Kavassery	January 2006	51
	February 2006	100
	March 2006	50
	June 2006	100
	July 2006	300

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The emerged cercariae were observed under phase-contrast objectives of a Carl Zeiss Axioscope 2 plus Trinocular Research Microscope for detailed study. Intramolluscan stages were also studied. Measurements are taken from 10% formalin-fixed cercariae and given in micrometres (μm) with mean values in parentheses. Sketches were drawn with the aid of a camera lucida. The new species of cercariae are designated by Roman numerals, followed by Malabar to indicate the region of collection.

Results and discussion

Cercaria sp. IX Malabar n.sp.

Host: *Thiara tuberculata* (Mueller)

Site of infection: Hepatopancreas

Locality: Malampuzha in Palakkad district, Kerala

Period of collection: December 2005–August 2006

Prevalence of infection: Twenty-one of 1561 (1.4%) snails collected were infected

Natural infection by this cercaria was found in 21 of 960 snails collected from Malampuzha. Six hundred and one snails collected from Kavassery were free from this infection. Cercariae emerged from snails throughout day and night with maximum emergence during 10 am–2 pm. Cercaria swims actively by lashing movements of its tail. Cercariae secret mucin, remain entangled in it and moved in groups.

Description: (Fig. 1)

Virgulate xiphidiocercaria

Body ovoid, spinose, $66\text{--}86 \times 23\text{--}46$ (69×34) in size. Tail spinose, with spines arranged closely toward the tail tip measures, $63\text{--}99 \times 8\text{--}10$ (86×9) in size. Oral sucker round, $25\text{--}30$ (27) in diameter. Stylet prominent, inserted into the roof of oral sucker; stylet walls reinforced except at the basal bulbous portion; $18\text{--}21$ (19) long and 3–6 (5) wide; shaft $10\text{--}12$ long; shoulders moderately developed, 5 wide. Virgula organ V-shaped, situated below the stylet; $3\text{--}5 \times 6\text{--}8$ (4×7) in size. Ventral sucker post-equatorial, $11\text{--}15$ (13) in diameter. Mouth sub-terminal, ventral. Pre-pharynx $3\text{--}5$ (4) long. Pharynx globular, muscular, $10\text{--}13$ (11) in diameter. Oesophagus $20\text{--}26$ (25) long. Caeca $13\text{--}25$ (22) long, 3–5(4) wide, reaching to the posterior level of ventral sucker. Penetration glands 3 pairs; anterior pair pre-acetabular and posterior two pairs para-acetabular in position; each gland with prominent nucleus and granular contents. Cystogenous glands numerous, round, with granular contents. Genital rudiments X-shaped, just behind ventral sucker. Excretory bladder reniform. Excretory tubules and flame cells not discernible.

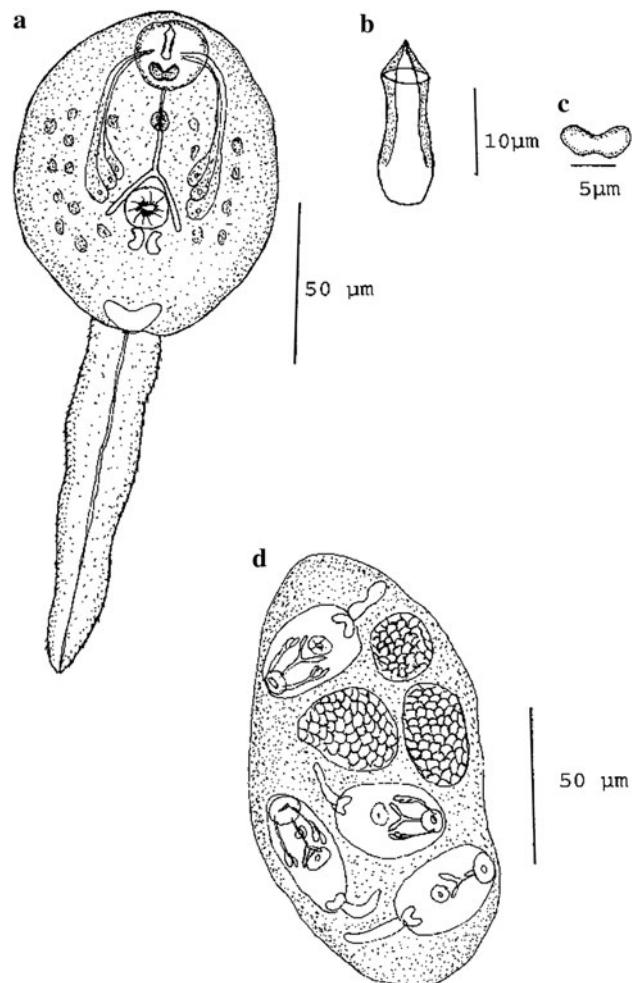


Fig. 1 *Cercaria* sp. IX Malabar sp. **a** Cercaria **b** Stylet **c** Virgulan organ **d** sporocyst

Sporocyst

Sporocysts were recovered from the hepatopancreas of the same snail host. Sporocysts oval to elongate, sac-like, $116\text{--}324$ (240) long, $85\text{--}216$ (132) wide. Sporocysts enclosed 3–6 developing cercariae and a few germ balls at various stages of development.

Remarks

Among the known virgulate Xiphidiocercariae with 3 pairs of penetration glands and spinose body, the present cercaria comes close to the description of cercaria of *Acanthatrium oregonense* by Burns (1961), *Cercaria dracodysiana* by Hall and Groves (1963), *C. etgesi* by Nasir (1963) and *C. melanopsi* III by Ismail and Abdel-Hafez (1983). The present form is distinct from the others in size of body and stylet, shape of virgula organ, arrangement of penetration glands and in the nature of their contents.

Table 1 Comparison of *Cercaria* sp. IX Malabar n.sp. with its related species

Character	<i>Cercaria of Acanthairium oregonense</i> Burns 1961	<i>Cercaria dracodysiana</i> Hall and Groves 1963	<i>Cercaria ergesi</i> Nasir 1963	<i>Cercaria melanopsi</i> III Ismail and Abdel-Hafez 1983	<i>Cercaria</i> sp. IX Malabar n.sp.
Body	135–170 × 67–85; spinose, with at least 8 papillae with setae on each side	50–64 × 26–39; spinose, with at least 5 transverse rows of setiferous papillae	160–197 × 58–83; spinose	75–108 × 43–58; spinose, six long sensory bristles unevenly spaced on each side	66–86 × 23–46 (69 × 34); aspinose, papillae and setae absent with larger spines at tip
Tail	70–114 × 15–22; spinose, tip provided with enlarged bristles	52–81 × 7–12; aspinose	54–149 × 17–24; aspinose	23–80 × 15–17; with larger spines near tip	63–99 × 8–10 (86 × 9); spinose
Oral sucker	45–60 × 37–50	14–18 × 15–20	25–41	30–32	25–30 (27)
Stylet	17–22	12–15	23–25 × 7–9	16 × 4–5	18–21 × 3–6
Virgula organ	35–52 × 37–50; with two elongated convoluted dough-nut shaped ring united anteriorly by a bridge	4.9 × 4.7; right and left halves fused posteriorly, tenuiform, in living specimen; saccate after fixation	Two pear-shaped structures fused anteriorly	Bilobed, non granulated	6–8 × 3–4 (7 × 4); V-shaped fused posteriorly
Ventral sucker	20–25	10–14	17–23	25–37	11–15 (13)
Penetration glands	3 pairs, anterior and lateral to ventral sucker; anterior pair finely granular, middle pair hyaline and posterior pair coarsely granular	3 pairs, pre and para acetabular; to ventral sucker; with fine granules	3 pairs, lateral to ventral sucker; anterior pair coarse granular middle pair hyaline, posterior pair finely granular	3 pairs, anterior 2 pairs with coarse granules, posterior pair, larger with fine granules	3 pairs, anterior and lateral to ventral sucker, sucker, coarsely granular
Excretory bladder	V-shaped	V, U or Crescent-shaped	V-shaped	Reniform, 22–25 × 15–17	Reniform
Host	<i>Oxytrema silicula</i> (Gould)	<i>Nitocris dilatatus</i> Conrad	<i>Pomacea glauca</i> (L.)	<i>Melanopsis praemorsa</i> (L.)	<i>Thiara tuberculata</i> (Mueller)

Comparative characters of the cercariae presented in Table 1 shows that cercaria of *A. oregonense*, *C. dracodysiana* and *C. melanopsi* III differ from the present cercaria in the absence of intestine. Cercaria of *A. oregonense* and *C. dracodysiana* further differ in the presence of setiferous papillae on body and V-shaped excretory bladder, and *C. melanopsi* III in having six pairs of long sensory bristles on body. *C. etgesi* differs from the present cercaria in having aspinose tail and V-shaped excretory bladder. Besides, the snail host of the present form is different from that of the other cercariae.

It is evident that the cercaria under report is different from other related forms, and therefore, it is reported here as a new species and named *Cercaria* sp. IX Malabar n.sp.

Cercaria sp. X Malabar n.sp.

Host: *Thiara tuberculata* (Mueller)

Site of infection: Hepatopancreas

Localities: Malampuzha and Kavassery in Palakkad district, Kerala

Period of collection: December 2005–August 2006

Prevalence of infection: Forty-five of 1561 (2.9%) snails collected were infected

Natural infection by this cercaria was found in 25 of 960 snails collected from Malampuzha and 20 of 601 snails collected from Kavassery in Palakkad district. Cercariae emerged in small numbers throughout day and night, but in large numbers from 9 am to 1 pm. Cercaria swims actively by lashing activity of its tail. At rest they remained suspended in the water column. Cercaria exhibited creeping movements on glass slide with a thin film of water and at the bottom of the container.

Description: (Fig. 2)

Virgulate xiphidiocercaria

Body elongate-oval, spinose, 99–132 × 76–92 (119 × 80) in size. Tail spinose, with the number of spines increasing toward tail tip; 89–125 × 17–26 (113 × 20) in size. Oral sucker round, 27–33 (30) in diameter. Stylet prominent, inserted into the roof of oral sucker; stylet walls reinforced except at the basal bulbous portion; 14–17 long, 3 wide; shaft 10 long; shoulders moderately developed, 3 wide. Virgula organ butterfly-like, situated below the stylet; 11–14 (12) long and 6–9 (8) wide. Ventral sucker post-equatorial, round, 17–27 (21) in diameter. Mouth subterminal, ventral. Prepharynx short, 3–5(4) in length. Pharynx globular, muscular, 9–13 (12) in diameter. Oesophagus 23–33 (25) long. Caeca 25–33 (30) long, 10 wide ending at anterior level of ventral sucker. Penetration glands 3 pairs, lateral to ventral sucker; each gland with prominent nucleus; anterior and posterior pairs with coarsely granular contents, middle pair hyaline.

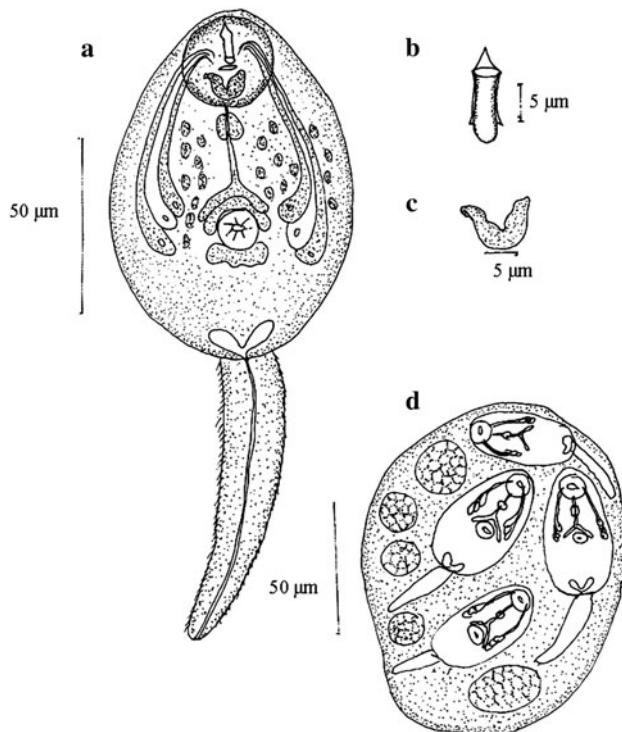


Fig. 2 *Cercaria* sp. X Malabar sp. **a** Cercaria **b** Stylet **c** Virgulan organ **d** Sporocyst

Genital rudiments consist of groups of cells at anterior and posterior margins of ventral sucker. Excretory bladder V-shaped. Flame cells not discernible.

Sporocyst

Sporocysts were recovered from hepatopancreas of *Thiara tuberculata*. Sporocysts oval to elongate, sac-like, 99–248 (190) long, 73–168 (136) wide, enclosing 4–10 cercariae and 3–9 germ balls at different stages of development.

Remarks

The present virgulate xiphidiocercaria with 3 pairs of penetration glands and V-shaped excretory bladder needs comparison with the descriptions of the cercaria of *Acanthatrium oregonense* by Burns (1961), *Cercaria gyrinoides* by Burns (1961), *C. dolomeda* by Hall and Groves (1963) and *C. levantiana* 4 by Lengy and Stark (1971).

From a comparison of characters of the present form with that of the above four species presented in Table 2, it is clear that the present form could be distinguished from the cercaria of *Acanthatrium oregonense* and *Cercaria gyrinoides* in body size, shape and size of stylet and virgula organ, in the absence of 8 pairs of setaceous papillae on body, in having intestinal caeca, and in the nature and distribution of penetration glands. *C. dolomeda* disagrees with the present form

Table 2 Comparison of *Cercaria* sp. X Malabar n.sp. with its related species

Character	<i>Cercaria of Acanthairium oregonense</i> Burns 1961	<i>Cercaria gyrioides</i> Burns 1961	<i>Cercaria dolomeda</i> Hall and Groves 1963	<i>Cercaria levantiana</i> 4 Lengy and Stark 1971	<i>Cercaria</i> sp. X Malabar n.sp.
Body	135–170 × 67–85; spinose, with at least 8 papillae with setae on each side	145–165 × 52–65; spinose, at least 8 setiferous papillae	102–162 × 44–77; spinose with at least 5 transverse rows of setiferous papillae	78–106 × 50–78; aspinose, sensory bristles absent	99–132 × 76–92 (119 × 80) spinose, sensory bristles absent
Tail	70–114 × 15–22; spinose, tip provided with enlarged bristles	62–96 × 15–20; spinose, tip provided with short bristles	88–134 × 13–22; tip with a tuft of 2–6 long refractile spines	53–147 × 16–20; spinose, sensory bristles absent	89–125 × 17–26 (113 × 20); spinose, with large number of spines at tip, sensory bristles
Oral sucker	45–60 × 37–50	57–73 × 42–55	28–35 × 26–35	32–34	27–33 (30)
Stylet	17–22	20–25	20–24	25, thick walled, dagger shaped	14–17 × 2–3
Virgula organ	35–52 × 37–50; with two elongated convoluted doughnut shaped ring united anteriorly by a bridge	48–65 × 42–55; two lobed sacs, not fused posteriorly	9–18 × 8–18, saccate, its right and left halves fused posteriorly.	26–30; bilobed	11–14 × 6–9 (12 × 8) butterfly-like
Ventral sucker	20–25	18–25	14–19	20–22	17–27(21)
Penetration glands	3 pairs, anterior and lateral to ventral sucker; anterior pair finely granular, middle pair hyaline and posterior pair coarsely granular	3 pairs; anterior and lateral to ventral sucker, anterior pair coarsely granular middle pair finely granular, posterior pair hyaline.	3 pairs, lateral and posterior to ventral sucker, first 2 pairs coarse granular and third pair hyaline.	3 pairs, arranged symmetrically on both side of the body, anteriormost pair smallest, flask shaped, do not extend beyond the posterior margin of oral sucker. The remaining 2 pair sausage shape like in the region of ventral sucker	3 pairs, arranged anterior and lateral to ventral sucker. Anterior and posterior pairs coarsely granular, middle pair hyaline.
Excretory bladder	V-shaped	V-shaped	Crescent-shaped or V-shaped to truncated	U to V-shaped	V-shaped
Host	<i>Oxytrema silicula</i> (Gould)	<i>Oxytrema silicula</i> (Gould)	<i>Nitocris dilatatus</i> (Conrad)	<i>Meranopsis praemorsa</i> (L.)	<i>Thiara tuberculata</i> (Mueller)

in body size, shape and size of stylet and virgula organ and in the presence of 5 transverse rows of setaceous papillae on the body. *C. levantiana* 4 is different in having aspinose body and tail and in the nature and distribution of penetration glands. Besides, the snail hosts used by these five cercariae are different.

As the present cercaria could not be identified with any of the known cercariae, it is considered as new and named *Cercaria* sp. XI Malabar n.sp.

Cercaria sp. XI Malabar n.sp.

Host: *Thiara tuberculata* (Mueller)

Site of infection: Hepatopancreas

Locality: Kavassery in Palakkad district, Kerala

Period of collection: December 2005–August 2006

Prevalence of infection: Twenty-five of 1561 (2.9%) snails collected were infected

Natural infection by this cercaria was found in 25 of 601 snails collected from Kavassery in Palakkad district. Nine hundred and sixty snails collected from Malampuzha are free from this infection. Cercariae emerged in small numbers throughout day and night, but in large numbers from 9 am to 11 am. Cercaria swims actively by lashing movements of its tail.

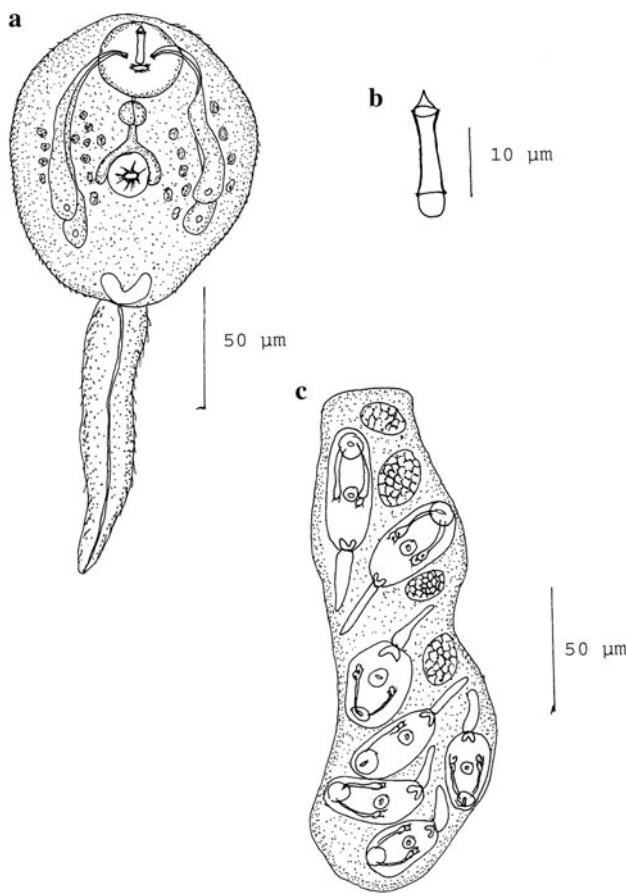


Fig. 3 *Cercaria* sp. XI Malabar sp. **a** Cercaria **b** Stylet **c** Sporocyst

Table 3 Comparison of *Cercaria* sp. XI Malabar n.sp. with its related species

Character	<i>Cercaria naukuchiensis</i> Malaki and Singh 1962	<i>Cercariae diglandula</i> Pandey 1967	<i>Cercaria levantiana</i> 3 Lengy and Stark 1971	<i>Cercaria craigi</i> Haseeb 1984	<i>Cercaria</i> sp. XI Malabar n.sp.
Body	103–116 × 10–84; spinose	112–117 × 36–48; spinose	60–147 × 21–54; aspinose, covered with sensory hairs	86–114 × 57–63; spinose	109–149 × 66–116; (126 × 94) spinose
Tail	84–130 × 12–20; aspinose	88–140 × 20–24; spinose	21–105 × 81–120; sensory hairs absent	89–106 × 14–17; aspinose	99–132 × 20–35; (133 × 33); spinose, distributed uniformly
Oral sucker	32–40	24–25 × 23–24	19–21	26–29–23–31	26–36 (32)
Stylet	16–20	16–20; Javelin shaped	14	17–20	20–23 × 3–5 (22 × 4)
Ventral sucker	20–24	24–26 × 20–24	13–17	17–26	17–24 (20)
Pharynx	10–15	20–22 × 15–17	6	Present	10–14(13)
Penetration glands	2 pairs, on either side of ventral sucker; anterior pair coarsely granular and posterior pair fine granular	2 pairs, lateral and posterior to ventral sucker; fine granular, anterior pair densely fine granular	2 pair on either side of ventral sucker; anterior pair coarsely granular and posterior pair finely granular	2 pairs, anterior to ventral sucker; granular in nature	2 pairs, posterior to ventral sucker, coarsely granular
Excretory bladder	Reniform	V-shaped	U-shaped	V-shaped	V-shaped
Host	<i>Melanooides tuberculatus</i> (Mueller)	<i>Melanopsis praemorsa</i> (L.)	<i>Melanopsis tuberculatus</i> (Mueller)	<i>Melanopsis tuberculata</i> (Mueller)	<i>Thiara tuberculata</i> (Mueller)

PLATE I

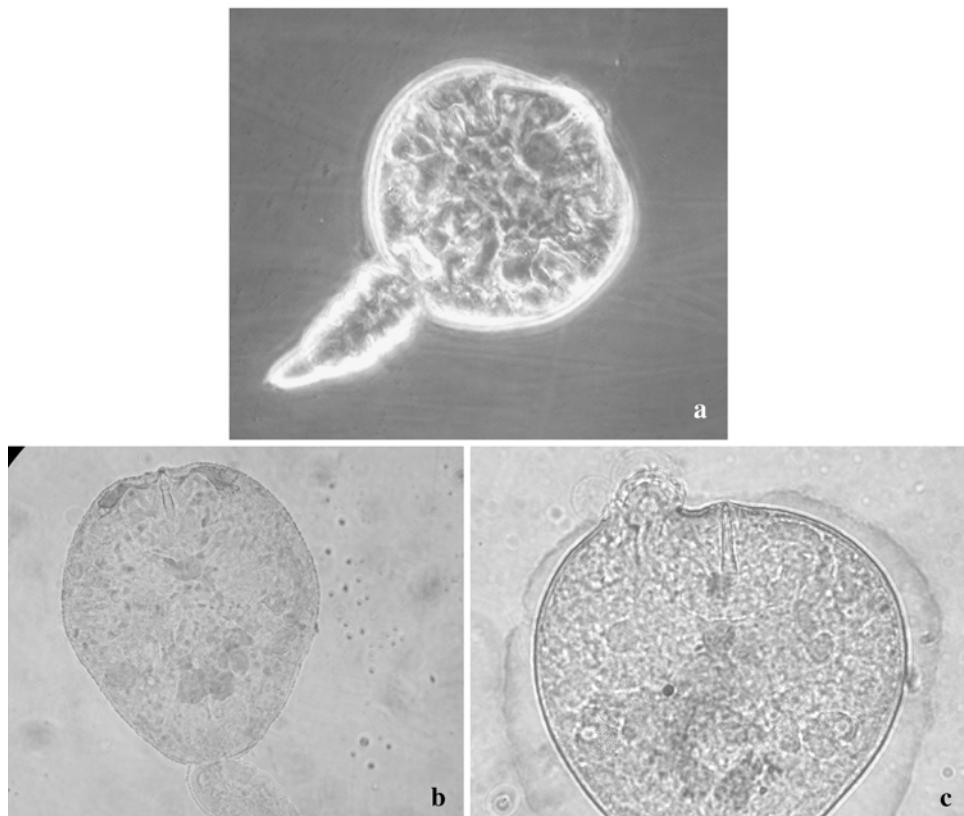


Fig. 4 **a** *Cercaria* sp. IX Malabar n.sp. **b** *Cercaria* sp. X Malabar n.sp. **c** *Cercaria* sp. XI Malabar n.sp.

Table 4 Comparative character of the 3 new species infecting *Thiara tuberculata*

Character	<i>Cercaria</i> sp. IX Malabar n.sp.	<i>Cercaria</i> sp. X Malabar n.sp.	<i>Cercaria</i> sp. XI Malabar n.sp.
Body	66–86 × 23–46 (69 × 34); spinose, papillae and setae absent	99–132 × 76–92 (119 × 80) spinose, sensory bristles absent	109–149 × 66–116; (126 × 94) spinose, sensory bristles absent
Tail	63–99 × 8–10 (86 × 9); spinose with larger spines at tip	89–125 × 17–26 (113 × 20); spinose, with large number of spines at tip, sensory bristles	99–132 × 20–35 (133 × 33); spinose, distributed uniformly
Oral sucker	25–30 (27)	27–33 (30)	26–36 (32)
Stylet	18–21 × 3–6	14–17 × 2–3	20–23 × 3–5 (22 × 4)
Ventral sucker	6–8 × 3–4 (7 × 4); V-shaped fused posteriorly	11–14 × 6–9 (12 × 8) butterfly-like	17–24 (20)
Pharynx	11–15 (13)	17–27 (21)	10–14 (13)
Penetration glands	3 pairs, anterior and lateral to ventral sucker, coarsely granular	3 pairs, arranged anterior and lateral to ventral sucker. Anterior and posterior pairs coarsely granular, middle pair hyaline.	2 pairs, posterior to ventral sucker, coarsely granular.
Excretory bladder	Reniform	V-shaped	V-shaped

Description: (Fig. 3)

Non-virgulate xiphidocercaria

Body elongate-oval, spinose, 109–149 × 66–116 (126 × 94) in size. Tail long, spinose, 99–132 × 20–35

(133 × 33) in size. Oral sucker round, 26–36 (32) in diameter. Stylet prominent, inserted into the roof of oral sucker; stylet walls reinforced except at basal bulbous portion; 20–23 (22) long, 3–5 (4) wide. Ventral sucker post-equatorial, round, smaller than oral sucker; 17–24 (20) in diameter. Mouth subterminal, ventral. Prepharynx 5–14

(8) long. Pharynx globular, muscular, 10–14 (13) in diameter. Oesophagus 20–28 (23) long. Caeca 33–46 (37) long, terminating at mid level of ventral sucker. Penetration glands two pairs, posterior to ventral sucker, with their ducts opening near stylet base; each gland with prominent nucleus and coarsely granular contents. Cystogenous glands numerous, round, with granular contents. Genital rudiments represented by irregular masses of cells situated at anterior and posterior margins of ventral sucker. Excretory bladder V-shaped.

Sporocyst

Sporocysts were recovered from hepatopancreas of host snails. Sporocysts elongate, cylindrical, measured 160–215 (193) long, 83–132 (98) wide; enclosed 5–8 cercariae and a few germ balls at different stages of development.

Remarks

Of the non-virgulate Xiphidiocercariae with 2 pairs of penetration glands, the present form comes close to the descriptions of *Cercaria naukuchiensis* by Malaki and Singh (1962) *C. diglandula* by Pandey (1967), *C. levantiana* 3 by Lengy and Stark (1971) and *C. craigi* by Haseeb (1984). But it is different from the related cercariae in body size, shape and size of stylet and in the nature and distribution of penetration glands.

Comparative characters of the 5 cercariae presented in Table 3 shows that *Cercaria naukuchiensis* differs from the present cercaria in the absence of intestine and in the presence of reniform excretory bladder. Further the present cercaria distinctly differs from *C. levantiana* 3 in having spinose body and V-shaped excretory bladder and from *C. craigi* in having spinose tail. In the light of the above observations the present cercaria is considered as a new species and the name *Cercaria* sp. XI Malabar n.sp., is proposed for it (Plate 1).

In order to show the differences in characters of the three newly described species a comparison of characters of the three species is presented in Table 4.

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